MEMORANDUM

To: Amy Hambrick, U.S. EPA, Sector Policies and Programs Division/Natural Resources and Commerce Group

From: Roy Oommen, ERG

Date: June 2010

Subject: Estimation of Impacts for New Units Constructed Within Five Years After Promulgation of the SSI NSPS

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA), under section 129 of the Clean Air Act (CAA), is required to develop new source performance standards (NSPS) regulating emissions of nine pollutants and opacity from sewage sludge incineration (SSI) units: hydrogen chloride (HCl), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), particulate matter (PM), dioxins/furans (CDD/CDF), nitrogen oxides (NO_x), and sulfur dioxide (SO_2). This memorandum describes the estimation of cost and emission impacts of complying with the NSPS. Section 2.0 discusses the estimation of the number of new sources that may be constructed within five years after promulgation of the SSI NSPS. Section 3.0 discusses the methodology used to estimate cost and emissions reductions from complying with the maximum achievable control technology (MACT) floor level of control required in the NSPS, and Section 4.0 discusses control options more stringent than the MACT floor level of control.

2.0 ESTIMATION OF NEW SOURCES

Several significant changes have occurred to SSI units in the past 20 years. The U.S. EPA's Office of Water (OW) set emission and discharge standards for sewage sludge disposal methods (including incineration) in 1993 (40 CFR part 503). As a result of the 503 rule, many wastewater treatment facilities chose to use alternative methods for disposing of sewage sludge, such as landfilling or land application, rather than try to meet the incineration requirements. Many of the closed incinerators had been operated by municipalities or agencies serving smaller populations, i.e., less than 50,000 people.[1]

The general trend has also been for facilities still incinerating sewage sludge to replace older multiple hearth (MH) units with newer fluidized bed (FB) units because of better emissions performance, savings in fuel cost, and flexibility in operation. Since 1988, there have been over 40 new FB systems installed, with 11 replacing existing MH units.[2] Discussions with the National Association of Clean Water Agencies (NACWA), the industry trade group, indicated that only FB units are likely to be constructed in the future.[3] Consequently, it was assumed that any new units that would be built after promulgation of the NSPS would be a FB design.

In order to estimate the number of new sources that may be constructed in the five years following promulgation of the NSPS, the number of sources being constructed five years prior to proposal of the rule was reviewed to determine if there was a trend. Under EPA's "New Source Review" (NSR) program, if a company is planning to build a new plant or modify an existing plant such that air pollution emissions will increase by a large amount, then the company must obtain an NSR permit. The NSR permit is a construction permit which requires the company to minimize air pollution emissions by changing the process to prevent air pollution and/or installing air pollution control equipment. The NSR program defines control levels based on the type of program the source is subject to: reasonably available control technology (RACT), best available control technology (BACT), or lowest achievable emissions reduction (LAER). Information from the EPA's RACT/BACT/LAER database contains case-specific information on the "Best Available" air pollution technologies that have been required to reduce the emission of air pollutants from stationary sources. This information has been provided by State and local permitting agencies. The database was searched for sewage sludge incineration units permitted or constructed since 2005. The search results showed two fluidized bed (FB) units at the R.L. Sutton Water Reclamation facility in Georgia were permitted in 2005 and completed construction in 2008 and are currently in operation.[4] Additional information collected from State environmental agencies and permits indicated an additional 3 units at the Mill Creek Wastewater Treatment Plant in Ohio were expected to finish construction and be in operation in 2010.[5] All of these new FB units were replacements for MH units.

Based on the data collected, and assuming the trend in construction continues, five additional FB units will be permitted to be constructed in five years after the NSPS is proposed. However, given the time necessary to review and assess the requirements of the NSPS and plan, permit, and construct incineration units, it is unlikely that all five would be in operation in the five years. For this analysis, it was assumed at least two new FB units would be constructed and in operation in this time period.

3.0 METHODOLOGY USED TO ESTIMATE COST AND EMISSION REDUCTIONS OF THE MACT FLOOR LEVEL OF CONTROL.

Cost and emission reductions for new units complying with the NSPS were calculated by: (1) determining the controls that these units would most likely apply if the NSPS were not in place (referred to as the baseline level of control), (2) calculating the cost of complying with the NSPS emission levels, and (3) estimating the emissions reduction from complying with the NSPS emissions levels. Each of these steps is discussed in more detail.

3.1 Determining Baseline Controls

The baseline level of control that new units would likely implement (in the absence of the NSPS) was determined from reviewing the most common controls used at existing FB units, as shown in the SSI inventory memorandum.[1] Table 3-1 shows the distribution of controls. Based on this information, the baseline controls assumed for the new units are a combination of venturi scrubbers and impingement scrubbers. Data gathered on the controls currently used at FB units indicates that few FB units operate an afterburner, because their CO emissions are already low. However, in order to meet the new source floor limit, the analysis costs out an afterburner to reach the limit. In reality, new FB units that are constructed are likely to be designed to meet the CO level. Costing an afterburner provides a conservative estimate of costs.

3.2 Calculating Baseline Emissions

The SSI baseline emissions memorandum[6] documents the calculation of baseline emissions from existing FB SSI units. Baseline emissions are calculated on a mass basis by multiplying the concentration of the pollutant in the emission stream, flow rate of the emission stream, and the hours of operation of the SSI unit. For units where no emissions test data were collected, baseline emissions were estimated using an average uncontrolled concentration and applying reduction efficiencies associated with the control devices located at each SSI unit for each pollutant.

An average flue gas flow rate factor was also developed for FB units relating the flue gas flow rate to the dry sludge feed rate from units providing emission test data. For units where sludge feed rates were not collected, unit capacities were multiplied by a capacity utilization factor of 75 percent, which was the median of the capacity utilizations reported in the ICR survey responses. More information about how unit capacity values were obtained can be found in the SSI inventory database memorandum.[1] The flow rate of the flue gas stream was calculated by multiplying the dry sludge feed rate by the average flue gas flow rate factor.

Based on the information gathered from RACT/BACT/LAER and permits, it is likely that new FB units constructed will be replacements for existing units. However, it cannot be determined how many units will be replaced at a facility or the total number of units that will be in operation at a facility. For this analysis, the simplest and most conservative assumption was used, that only one FB unit would be constructed replacing one older MH unit. The operating hours for facilities operating one unit was assumed to be 8400 hours per year (incorporating two weeks downtime).

Table 3-2 shows the average concentration factors, average dry sludge capacity, and operating hours, as well as other default parameters necessary for the costs. These factors were applied to each new unit estimated to be constructed within the next five years. Table 3-3 shows the estimated baseline concentrations for new units.

3.3 Calculating Costs and Emission Reductions

Costs were calculated using the procedures and algorithms discussed in the memorandum, "Cost and Emissions Reduction of Complying with the MACT Floor for Existing SSI Units".[7] Control devices costed out were those that would be necessary to meet the MACT floor level of control for new sources. It is possible for some units with wet scrubbers to comply with the NSPS limits for SO_2 by adding caustic. However, it is uncertain if all units could do this. Therefore, this analysis assumes a packed bed scrubber would be used, which would provide a more conservative estimate of costs. Similarly, wet electrostatic precipitators can be used for PM control; a FF was costed in this analysis to provide a conservative estimate of costs. Table 3-3 shows the comparison of baseline emissions levels to MACT floor levels to determine the amount of pollutant reduction needed and the types of control devices that would be used to meet the levels. Emission reductions from applying the MACT floor requirements to the baseline emission levels are presented in Table 3-3. The inputs to the cost algorithm are presented in Table 3-2. For this analysis, it was assumed that controls applicable for PM would also reduce $PM_{2.5}$.

Table 3-4 shows the estimated total capital investment (TCI) and total annual costs (TAC) calculated for a single unit using the cost algorithms previously discussed. The table also shows the monitoring, testing, reporting, and recordkeeping costs. The table shows the TCI and TAC for the two new FB units that are assumed to be constructed and in operation in the five years after proposal of the NSPS. Table 3-5 shows the detailed capital and annual costs of continuous CO emissions monitoring for each new SSI unit (continuous CO emissions monitoring costs were not presented in the "Cost and Emissions Reduction of Complying with the MACT Floor for Existing SSI Units" memorandum because it was an alternative monitoring requirement and not required) .

4.0 ANALYSIS OF BEYOND THE FLOOR OPTIONS

The control technologies costed to achieve the MACT floor levels are generally the most effective controls available: fabric filters for PM, Cd, Pb; activated carbon injection for Hg and CDD/CDF; afterburners for CO; and packed bed scrubbers for HCl and SO_2. In addition, incremental additions of activated carbon have not been proven to achieve further reductions above the projected flue gas concentration estimated to achieve the limits for new sources. Data gathered does not indicate that any FB units operate NO_x controls, such as selective noncatalytic reduction, selection catalytic reduction, or flue gas recirculation because the NO_x emissions are already low. Therefore, no beyond the floor options were analyzed for this analysis because we are not aware of any technologies or methods to achieve emission limits more stringent than the MACT floor limits for new units, which are based on the lowest emitting FB units.

5.0 REFERENCES

1. Inventory Database for the Sewage Sludge Incineration Source Category. Memorandum from Eastern Research Group to Amy Hambrick, U.S. Environmental Protection Agency. June 2010.2. A Comparison of Fluid Bed and Multiple Hearth Biosolids Incineration. Ky Dangtran, John Mullen, and Dale Mayrose. Paper presented at the 14th Annual Residuals and Sludge Management Conference. February 27-March 1, 2000, Boston MA.

3. Meeting minutes from Sewage Sludge Incinerator Informational Meeting with the National Association of Clean Water Agencies (NACWA). Research Triangle Park, NC. August 25, 2009

4. R.L. Sutton Water Reclamation Wastewater Treatment permit # 4953-067-0018-V-01-1 RACT/BACT/LAER Clearinghouse. http://cfpub.epa.gov/rblc/

5. Mill Creek Wastewater Treatment Plant. Final permit to install. Permit Applicatoin #14-05837.

6. Estimation of Baseline Emissions From Existing Sewage Sludge Incineration Units. Memorandum from Eastern Research Group to Amy Hambrick, U.S. Environmental Protection Agency. June 2010.

7. Cost and Emissions Reduction of Complying with the MACT Floor for Existing SSI Units. Memorandum from Eastern Research Group to Amy Hambrick, U.S. Environmental Protection Agency. June 2010.

Table 3-1. Control Device Distribution for Fluidized Bed Incinerators[1]

Existing Control Devices	# units	%
Distribution of Control Combinations		
abd - mc - vs - imp	2	3.64
abd - vs - imp - hss - cs	1	1.82
abo - imp - wesp	1	1.82
ac inject. - vs(ad) - wesp	3	5.45
ccpt	1	1.82
cs - vs - pbt	2	3.64
unknown	4	7.27
vs	5	9.09
vs - cs	1	1.82
vs - imp	25	45.45
vs - imp - wesp	8	14.55
vs- imp - wesp - ac polish.	1	1.82
vs(ad) - wesp	1	1.82
Total	55	100.00
Distribution of Individual Controls		
Venturi scrubber (vs, vs(ad))	49	0.89
Impingement scrubber (imp)	38	0.69
Wet ESP (wesp)	14	0.25
Cyclone separator (cs)	4	0.07
Activated carbon (ac inject or ac polish)	4	0.07
Afterburner (abo or abd)	4	0.07
Packed bed scrubber (ccpt, pbs, pbt)	2	0.04

Control Abbreviations:

Abbreviation	Control
abd	detached afterburner
abo	on-hearth afterburner
ac inject.	activated carbon injection for mercury control
ac polish.	activated carbon polishing for mercury control
agr	acid gas removal system
bag	baghouse
ccpt	counter-current packed tower
cs	cyclone seperator
cs/tg	twin gas cyclonic scrubber
fgr	flue gas recirculation
hjs	horizontal gas scrubber
hss	hydrosonic scrubber
imp	impingement tray scrubber
pbs	packed bed scrubber
pbt	packed bed tower
rto	regenative thermal oxidizer
vs	venturi scrubber
vs(ad)	venturi pak or ring jet scrubbers
wesp	wet electro static precipitator
whs	wet hydrosonic scrubber
ws	wet scrubber (undefined)
mc	multiclone

1 Email from Robert Dominak, Co‑Chair NACWA Biosolids Management Committee, to Amy Hambrick, U.S. EPA, on 8/5/2009: “SSI Inventory Updated Information.” Attachment: SSI_Inventory (RPD 8-5-09).xls

3-2. Cost and Emission Reduction Calcualtion Inputs

Parameter	Default (Average of known data for FB subcategory)
Capacity (dtph)	2.26
Capacity (dry lb/hr)	4516.36
Sludge Feed Rate (dry tons/hr)	1.69
Sludge Feed Rate (dry lb/hr)	3387.27
Operating Hours (hr/yr)[1]	8400
Stack Gas Flow Rate (dscfm)	9239.97
Stack Gas Temp (°F)[2]	1050
ACI Adjustment Factor[3]	1.03
Sludge Heating Value (btu/lb)[4]	7740
NOX, lb/MMBtu	0.07
PM (gr/dscf)	0.0054
HCl (ppmvd)	0.124

1. Conservatively assumed new unit would operate 350 days per year (2 weeks downtime).
2. Assumed average gas temperature used for commercial and industrial solid waste incinerators (CISWI)
3. ACI algorithm is based on 90% Hg reduction efficiency and 98% CDD/CDF reduction efficiency. This adjustment factor will be used to adjust total annual costs to the estimated reduction efficiency needed to meet the floor.
4. Converted to btu/lb from 18 MJ/kg dried, undigested sludge (http://www.aseanenvironment.info/Abstract/41015799.pdf)

Table 3-3. Summary of Emission Reductions for New SSI Units

Pollutant	Concentration Units	Additional Control Needed for MACT	Baseline Concentration	NSPS Limit	MACT Emission Concentration	Emission Reduction (concentration)	Emission Reduction (tpy)	Annual Emission Reductions: Year 5 (Assuming 2 new units come online in 5 years)
Cadmium (Cd)	mg/dscm	Add FF	0.002	0.00051	0.00051	0.002	2.36E-04	4.73E-04
Carbon Monoxide (CO)	ppmvd	Add ABD	16.331	7.4	7.4	8.931	1.51E+00	3.02E+00
Hydrogen Chloride (HCl)	ppmvd	none[1]	0.124	0.12	0.050	0.074	1.64E-02	3.27E-02
Lead (Pb)	mg/dscm	Add FF	0.011	0.00053	0.00053	0.011	1.53E-03	3.06E-03
Mercury (Hg)	mg/dscm	Add ACI	0.014	0.001	0.001	0.013	1.82E-03	3.64E-03
Nitrogen Oxides (NOx)	ppmvd	none[2]	27.926	26	26	1.926	5.35E-01	1.07E+00
Particulate Matter (filterable)	mg/dscm	Add FF	12.443	4.1	4.1	8.343	1.21E+00	2.43E+00
Particulate Matter (PM2.5)	mg/dscm	Add FF	11.801	2.3	2.3	9.501	1.38E+00	2.76E+00
Sulfur Dioxide (SO2)	ppmvd	Add PBS	3.303	2.0	2.0	1.303	5.04E-01	1.01E+00
Total Dioxin/Furans	ng/dscm	Add ACI	15.962	0.024	0.024	15.938	2.32E-06	4.63E-06
Total Dioxin/Furans (TEQ)	ng/dscm	Add ACI	1.312	0.0022	0.0022	1.310	1.90E-07	3.81E-07

1. Assumed Scrubber (installed for SO2 control) has 98% efficiency for HCl control
2. Assumed units could meet limit by making minor adjustments rather than installing add-on control
3. The NSPS Dioxin/Furans limits determined for MH units were used rather than the limits determined for FB units because MH limits reflect better performance.

Control Device Key:
FF = fabric filter
ABD = detached afterburner
ACI = activated carbon injection
PBS = packed bed scrubber

Table 3-4. MACT Costs Associated with Model FB Unit

Parameter		TCI	TAC
Controls	Add FF	$1,995,892	$580,670
	Add PBS	$1,013,167	$233,832
	Add ACI	$25,786	$163,338
	Add ABD	$625,106	$233,589
	Subtotal:	**$3,659,952**	**$1,211,429**
Monitoring, Testing, Reporting and Recordkeeping	Initial Stack Test	$61,000	
	Annual Stack Test		$61,000
	Bag Leak Detection System	$25,500	$9,700
	Wet Scrubber Monitoring	$24,300	$5,600
	ACI Monitoring	$0	$9,800
	Annual Control Device Inspection		$1,000
	CO CEMS	$134,000	$41,400
	Annual Visual Emissions Test of Ash Handling	$250	$740
	Reporting and Recordkeeping		$2,989
	Subtotal:	**$245,050**	**$132,229**
TOTAL:		**$3,905,002**	**$1,343,657**

Assuming 2 new units come online in 5 years:

Total TCI after 5 year:	**$7,810,003**	
5th Year TAC:		**$2,687,314**

Control Device Key:
FF = fabric filter
ABD = detached afterburner
ACI = activated carbon injection
PBS = packed bed scrubber

Table 3-5. CO Continuous Emissions Monitoring Costs

Parameters/Costs		Equation	CO CEMS
A. Parameters			
	1. Recording lime/carbon flow, min/4-hr period		
	2. Annual operating hours, hr/yr (H)		
	3. Cost index		
	a. 2008		575.4
	b. 2006		499.6
	c. 1997		386.5
	d. 1993		359.2
	e. 1992		358.2
	4. Operating labor wage rate, $/hr (LR)		$34.60
	5. Capital recovery factor, 20-yr equipment life, 7% interest (CRF)	= $[i \times (1 + i)^a] / [(1 + i)^a - 1]$, where i = interest rate, a = equipment life	0.09439
B. Total Capital Investment, $ (TCI)			
	1. Planning		$4,000
	2. Select type of equipment		$10,000
	3. Provide support facilities		$20,600
	4. Purchased equipment cost (PEC)		$48,400
	5. Install and check equipment		$18,200
	6. Perf. spec. tests (certif.)		$15,700
	7. Prepare QA/QC plan		$17,500
	8. Total capital cost	= Planning + selecting equipment + support facilities + PEC + installation + perf. spec. tests + QA/QC plan	$134,000
C. Annual Costs, $/yr			
	1. Operating labor	= (5 min to record lime/carbon flow/4-hr period) x (1 hr/60 min) x H x LR	
	2. Maintenance materials	= 0.02 x TCI	
	3. Operation & maintenance	= Day-to-day activities + annual RATA + CGA + annual QA + O&M review and update	$27,600
	4. Recordkeeping and reporting	= $1,000 x (525.4/386.5)	$1,200
	5. Overhead	= 0.6 x (labor + maintenance materials)	
	6. Property taxes, insurance, and administration	= 0.04 x TCI	
	7. Capital recovery	= CRF x TCI	$12,600
	8. Total annual cost	= Operating labor + maintenance materials + recordkeeping and reporting + overhead + property taxes, insurance, and administration + capital recovery	$41,400

Notes:
1. Monitoring costs have been rounded to the nearest $100 to be consistent with level of rounding in original costs.

Sources:
1. Hospital/Medical/Infectious Waste Incinerators (HMIWI) [EPA-HQ-OAR-2006-0534] Testing and Monitoring Options and Costs Memo (IV-B-66).
2. E-mail and attachment from Peter Westlin, EPA, to Mary Johnson, EPA. August 19, 2008. Monitoring Options for SNCR on Medical Waste Incinerators.
3. E-mail from Dan Bivins, EPA, to Mary Johnson, EPA. September 27, 2006. Cost of CO CEMS.

4. E-mail from Dan Bivins, EPA, to Mary Johnson, EPA. July 28, 2006. Some Preliminary Thoughts on the HWI Monitoring.